PTFE Faced Thrust Bearings – an OEM's Viewpoint

by

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Abstract

PTFE-faced thrust bearings are already well established in various parts of the world and gaining rapid ground as an alternative to the more conventional babbitt-lined bearings for major hydrogenerator installations.

Michell Bearings has been developing PTFE-faced thrust bearings for a number of years with most early applications being found in refit projects to overcome performance limitations in existing equipment. At an early stage in the development process Michell Bearings formed a strategic relationship with Fuji Electric (now Voith Fuji Hydro Power Generation) in Japan for the joint development of PTFE-faced bearings for cost-effective incorporation in new build Fuji machines.

This paper gives a brief background to the development of the PTFE-faced thrust bearing and their successful application in a range of new hydrogenerator programmes. The design of the pad and the design duties are described along with operational experience where this is relevant. In preparing this paper the authors have sought to provide an integrated perspective on PTFE-faced thrust bearings as seen from the bearing supplier and from the machinery manufacturer alike.

Introduction

For many years whitemetal or Babbitt has been used as the principal, working face lining material for hydrodynamic, oil lubricated bearings. Indeed the use of babbitt pre-dates the invention of the tilting pad bearing at the beginning of the last century and was, for example the material used on the bearing faces of the vast multi-collar, plain bearing thrust blocks characteristic of naval vessels before the 1920's. Of course, the development of fully hydrodynamic bearings means, in theory, that any dimensionally stable and sufficiently strong material can be used for the load carrying surfaces of a bearing, which are separated by a fluid film. Babbitt has remained popular, however, because of its low break-out friction, its ability to tolerate embedded debris and the ease with which it can be repaired or replaced should this become necessary. Nevertheless a number of different materials have been experimented with over the years and it is polytetraflouroethylene (PTFE) that is making significant inroads particularly for demanding hydrogenerator installations.

Michell Bearings has been developing PTFE-faced thrust bearings since 1996 (1), starting with relatively small scale laboratory tests and progressing to full scale testing on a purpose built rig, followed by a number of full size, field applications (2). At an early stage in this process Michell Bearings formed a strategic relationship with Fuji Electric (later Voith Fuji Hydro Power Generation) in Japan for the joint development of these bearings for incorporation in Fuji machines. It is significant that whereas a number of the early PTFE-faced bearing applications encountered by Michell were for retro-fitting to existing facilities, typically to counteract some operational limitations (3), the relationship with Fuji was based around bearing applications in new machines.

The initial decision by Fuji Electric and Michell to work together on the development of the PTFE-based bearings required a clear commitment on both sides with transparency of data and information through the product introduction cycle. Fuji Electric have an additional long-term interest in the use of PTFE-faced bearings in association with their own advanced bearing design using magnetic uplift. In this case there is a need for a back-up bearing to endure severe, but occasional duties, in the case of power failure (black shutdown). The tolerant nature of PTFE appears to be ideally suited for this duty. In addition the high pressures possible allow smaller thrust pads to be used. This has the additional benefit of reducing energy loss, thereby increasing machine efficiency.

The relationship between Fuji and Michell, as machinery manufacturer and bearing supplier respectively, has matured to the point that there is now a significant portfolio of new Fuji hydrogenerator installations that make use of Michell PTFE-faced thrust bearings. The end users are all power authorities in the Japanese hydro power community. At the time of writing the project list is as shown in Table1.

Power Station	Power Authority	Turbine Type	Output (MVA)	No. Of Units	Rotational Speed (rpm)	Installation Date
Hidaka	Hokkiado Electric	Kaplan	10.6	1	500	Apr 1998
Gassan	Tohoku Electric	Deriaz	9.3	1	500	Dec 2000
Kaminojiri	Tohoku Electric	Vertical Bulb (world's first)	13.5	1	167	Jun 2002
Ohno (rehab project)	Kyoto Electric	Kaplan	12.6	1	400	Feb 2003
Otaki	Kansai Electric	Kaplan	11	1	514.3	Mar 2003
Matsuyama	Kyushu Electric	Kaplan	0.875	1	450	Oct 2003
Shinkoara	Tohoku Electric	Deriaz	11.7	1	500	Nov 2003
Shinochiai	Tohoku Electric	Kaplan	25	1	273	Dec 2004
Kajigawa	Kufusu Electric	Francis	20	1	600	Dec 2004

Table 1: Fuji hydrogenerator projects incorporating Michell PTFE-faced thrust bearings 1998-2004

The end user companies responsible for the generation facilities listed Table 1 are very interested in the use of PTFE-faced bearings as a key technology within the equipment being purchased. Building confidence in the client community required machinery manufacturer and bearing supplier to work very closely together and in the initial stages present the technology jointly to the prospective purchasers.

The Voith Fuji Thrust Bearing

The thrust bearings developed in partnership between Voith Fuji and Michell for use in new machinery bring together the Michell PTFE working face technology referred to above with established underlying bearing system design technology commonly used by Fuji.

Typically, the design of the Fuji hydrogenerator bearing employs spring plates to support the thrust pads and allow for deflection under load to create the necessary hydrodynamic film between the pads and rotating thrust collar, as shown diagrammatically in figure 1. The support plates are shaped like saucers. Depending on the magnitude of the thrust load and the required amount of deflection, each thrust pad is fitted with either one or two spring plates mounted one above the other. The set of upper spring plates is attached to the thrust pads by a retaining ring. All the installations listed in Table 1 are for uni-directional machines and for this reason the upper spring plates are positioned so that the pad supports are offset in the normal way for such equipment to maximise the effectiveness of hydrodynamic lubrication. The bottom of each upper spring plate is in the form of a flat frustum of a cone similar to the top of the lower spring plate. The use of spring plates allows a certain degree of pad to pad load equalisation. In the Fuji design the total deflection of the pad relative to the support structure is approximately 0.6 to 0.8 mm.

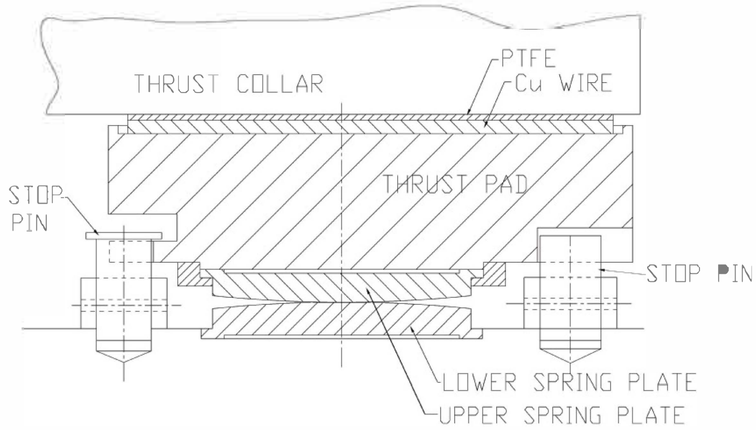

Figure 1: Thrust Pad with Spring Plate Support

Most of the projects listed in Table 1 utilise Fuji's normal spring support arrangement but it is worth noting that other designs have been also used with PTFE-faced technology. For example, the Kaplan turbine at Matsuyama uses a very traditional line pivot design, while the Francis turbine at Kajigawa has an elastic (rubber compound) support.

Figs 2 and 3 show the bearings for Kaminojiri and Shinkoara respectively at the installation phase.

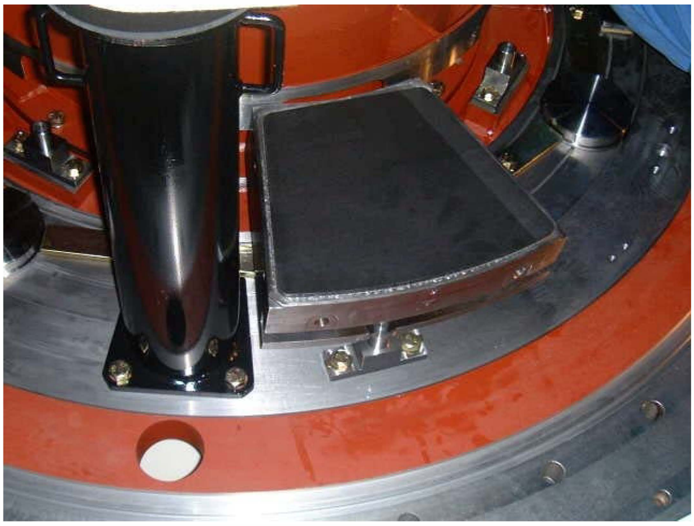

Figure 2: Kaminojiri